How is CMAQ Used to Support State and Tribe Implementation Plans for Regional Haze?

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research and development

Science Issues

The Clean Air Act requires that States develop implementation plans (optional for Tribes) using air quality results among a suite of analyses to demonstrate the projected 2018 increment of reasonable progress toward natural visibility conditions in mandatory federal Class I areas by 2064. CAA goals include improving monitored visibility on the worst days and preventing deterioration on the cleanest days. Numerical air quality simulation models are now routinely operated for polluted conditions for episodes of several weeks. However, the regional haze rule requires long term modeling (at least a full calendar year) and the models must also be validated for very clean conditions.

- *Can these models be routinely operated for a calendar year for both retrospective validation studies and future control scenarios?*
- *Can the models provide good performance for clean conditions?*
- *What are the criteria for acceptable performance?*
- *What grid resolution is required to obtain good model performance?*

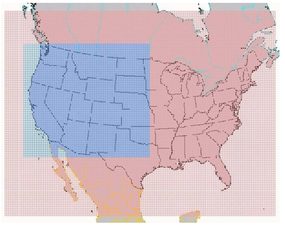
Research Goals

- Develop and evaluate annual modeling datasets for a continental scale 36-km grid and high resolution, nested 12-km grid.
- Evaluate models for calendar years 1996 and 2002 by comparing with all major ambient monitoring data networks.
- Develop protocol for applying Relative Reduction Factors for use in assessing future year emissions control scenarios.
- Develop emissions data for fires, ammonia and natural emissions, and evaluate the effects of updates in CMAQ simulations.

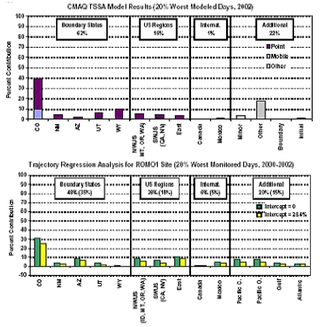
Methods/Approach

The states and tribes are regionally organized into 5 Regional Planning Organizations (RPOs) to collaborate on regional modeling studies to address interstate transport of fine particulates and their precursors that impair visibility. Each RPO supports a variety of researchers and contractor teams who contribute to the overall visibility research program. One of the key numerical air quality models (AQMs) used is the Models 3 Community Multiscale Air Quality (CMAQ). Simulated meteorology data is provided by operating the National Center for Atmospheric Research/Penn State University Mesoscale Model version 5 (MM5). Emission inventories are based on the National Emissions Inventory (NEI) with many updates and also include a variety of other emissions models, including the Biogenic Emissions Inventory System (BEIS), the MOBILE5 model, newly developed ammonia and wind blown dust models and other emissions datasets (e.g., data obtained from Canada, Mexico). Boundary conditions are provided by nesting the continental scale AQM in the global scale GEOS-CHEM model.

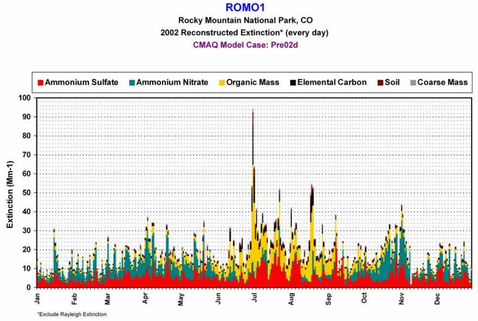
Continental domain 36-km grid and 12-km nest in the WRAP region.

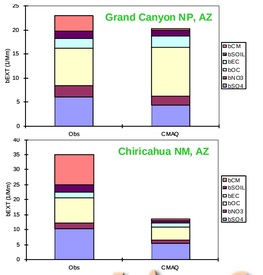


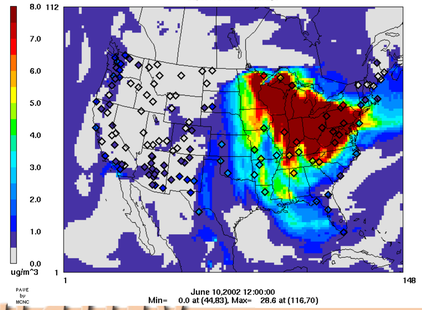
The Western Regional Air Partnership (WRAP) is funding multiple approaches to assess source apportionment to quantify contributions of local versus transported particulates. The tagged species algorithm (TSSA) implemented in CMAQ uses "tracers" for mass tracking. New EPA STAR Grant funding is supporting additional testing and development of the TSSA approach and extension of the algorithm to treat organic carbon aerosols.



Model evaluation is performed by comparing simulated concentrations to ambient monitoring data using a wide variety of approaches, including scatter plots, time-series, stacked bar plots, data overlay on spatial plots, and tables of model performance metrics. We continue to experiment with alternate forms of presenting model evaluation results in a way that most effectively communicates results to regulators and stake holders.

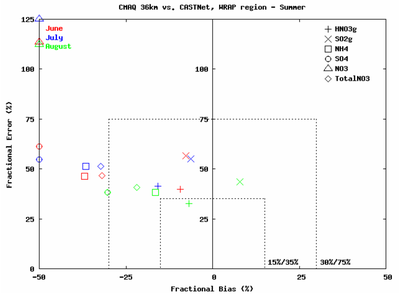


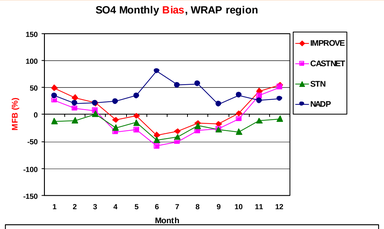


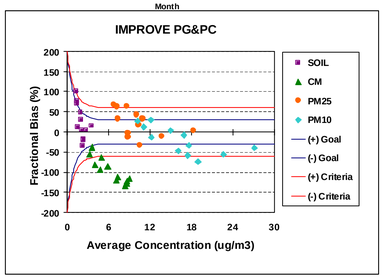


New approaches for model performance evaluation.

- Need to distinguish performance results between dirty vs. clean conditions.
- Some statistical performance metrics exaggerate over-predictions.
- No metric is perfect, but fractional bias is best.







Results/Conclusions

- Model performance in the western US is reasonably good for sulfate, elemental carbon, organic carbon. In some cases the errors are within the bounds of measurement uncertainty.
- Large errors and seasonal dependence of error in nitrate exist, these might be a result of errors in ammonia inventory. Large errors in coarse mass are likely due to uncertainty in emissions, local scale impacts and model/measurement inconsistencies.
- Long term modeling using CMAQ is now computationally feasible. However, uncertainties remain in emissions, meteorology, chemistry and deposition, as well as model formulation.

Future Directions

- Continue working to develop a protocol for defining acceptable model performance. Key issues include consensus on "best" performance metrics and performance goals for clean conditions.
- Model performance will not be perfect. We are developing a protocol for using relative reduction factors to assess benefits of emissions controls.
- N deposition results used in integrated studies of ecosystem effects.

Impact and Outcomes

- Published results of visibility modeling in Technical support document for use in Section 309 SIPs.
- Developed new emissions models for NH_3, wind blown dust, sea salt. New emissions QA package.
- Developed Model Performance Evaluation software package to automate model evaluation.
- Implemented new source apportionment algorithm in CMAQ.
- Modeling to support CAA Section 308 SIPs/TIPs is in progress.

Air Quality